Resource Management

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Wind Cave National Park Resource Management News

This issue edited by Beth Burkhart, Botanist, and Marie Curtin, Botany Technician






Caption: *The landscape in Wind Cave National Park includes woodlands, shrublands, and grasslands (center photo), with 28 plant communities described for the park. Members of prairie plant communities include (top row, left to right): shell-leaf penstemon (Penstemon grandiflorus), switchgrass (Panicum virgatum) and little bluestem (Schizachyrium scoparium). Vegetation management activities include (bottom row, left to right): monitoring vegetation condition and revegetation projects with native species. All photos in this issue are taken in Wind Cave NP by NPS staff unless otherwise noted.*

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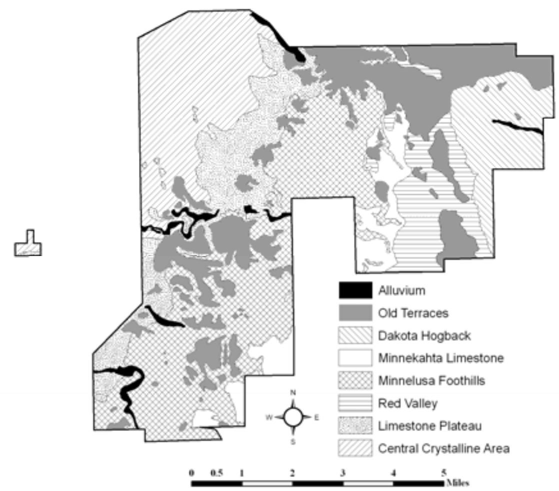
Wind Cave NP Vegetation – An Introduction

By Beth Burkhart

Vegetation in the area known today as the Northern Great Plains, including the Black Hills and Wind Cave National Park (in the southern Black Hills), has been shaped by multiple factors over a long period of time. Toward the end of the Pleistocene (commonly called the Ice Age), global warming caused glaciers to retreat northward. Boreal coniferous forests were replaced by deciduous forest and finally by grassland. The grassland character of the region was established roughly 12,000 years Before Present (BP).

The Black Hills have consistently received more precipitation than the surrounding plains (the Black Hills uplift predates the ecological formation of the Great Plains, occurring from 65 million to 35 million years BP). The increased precipitation and complexity of topographic relief in the Black Hills allowed the area to harbor plant species that could not adapt to the warmer, drier climate of the Great Plains during the Holocene – species that today have more boreal, western, or eastern distributions. Consequently, the Black Hills are recognized as a unique crossroads for plant species and identified as a unique ecoregional province (Black Hills Coniferous Forest Province) distinct from the surrounding Great Plains – Palouse Steppe Province (Descriptions of Ecoregions of the United States, Bailey 1995).

Wind Cave National Park is not a large area (28,295 acres), yet it contains segments of all five geomorphic regions recognized in the Black Hills. The Central Core area in Wind Cave National Park is composed mainly of ponderosa pine (*Pinus ponderosa*), forested uplands (with some stands of hardwoods including aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*) and bur oak (*Quercus macrocarpa*). The Limestone Plateau area includes mainly upland prairies, mountain mahogany (*Cercocarpus montanum*), chokecherry (*Prunus virginiana*)/American plum (*Prunus americana*) shrublands, and ponderosa pine/Rocky Mountain juniper (*Juniperus scopulorum*) woodlands (the land directly over Wind Cave is in the Limestone Plateau geomorphic region). The Minnekahta Foothills area is composed of deep canyons with ponderosa pine/Rocky Mountain juniper woodlands, chokecherry/American plum shrublands, and grassland vegetation. The Red Valley includes open, rolling prairie vegetation. The steep western slopes and gradual eastern slopes of the Hogback Ridge are vegetated with ponderosa pine/Rocky Mountain juniper woodlands and prairie vegetation. Riparian areas and wetlands do not cover a large percentage of the park's landscape because surface water is not common and often not permanent. However, the plant biodiversity that wetland plant communities contribute to the vegetation in the park is great. In addition, since water is vital to all biological life forms in the park, wetlands are more important to the park ecosystem than the proportion of the landscape they cover would seem to indicate. [Detailed information on the 28 plant community types in Wind Cave National Park can be found in the Black Hills Community Inventory Volume 2, Marriott and Faber-Langendoen 2000.]



Geomorphic diversity of Wind Cave NP helps support high native plant biodiversity (USGS Vegetation Mapping Program, Cogan et al. 1999).

The idea that the area of Wind Cave National Park was once isolated and pristine relative to its vegetation is attractive but false. The area is associated with a complex and changing human history extending back to prehistoric times. In the historic era from roughly 1742 to 1877, Lakotas, Cheyennes, and Arapahos were among many tribal nations who lived and traveled within reach of Wind Cave NP. The park today is one of the most sacred and culturally significant areas of the Black Hills to the Lakotas and Cheyennes. From about 1880 to 1930, the park area was home to European American homesteaders (Ethnographic and Ethnohistorical Study of Wind Cave NP, Albers 2003). The humans who interacted with the natural resources of the park area contributed to shaping its vegetation as their lives were in turn dependent on the vegetation.

Revegetation Projects in Wind Cave NP: Past, Present, and Future

By Beth Burkhart

Revegetation: PAST

It is estimated that between 1878 and 1883, the number of cattle in the Black Hills expanded from 100,000 to 500,000 on an "open range" basis (The Cattle Industry in the Black Hills, Palais 1942). Although many of the ranches were located in Fall River County, just south of Wind Cave NP area, it is difficult to tell how much the land within the park was affected due to the nature of open range operations. However, it is certain the park area was impacted. Continuous grazing in some areas without allowing the soil any chance for recuperation resulted in serious depletion of the range.

In May 1939, the practice of granting grazing permits to ranchers who previously owned land in the area [Custer Recreational Demonstration Area (RDA)] was discontinued to prevent erosion and to allow the range vegetation to recuperate. However, the area remained unfenced so grazing by free range livestock continued. A complete boundary fence for Wind Cave NP was not accomplished until 1951, after legislation signed in 1946 created the current boundaries of the park by adding part of the Custer RDA. In the late 1940's, the Soil Conservation Service collaborated with the park on a range restoration and management plan. A 1950s report identified the problems facing the park and attributed them to overgrazing and poor management. "The accelerated erosion was so advanced in the Red Valley area at time of acquisition for park purposes that usefulness of the soil for agricultural purposes was almost totally destroyed. The accelerated erosion has reached the severe and critical stage in some sections of the valley long before retirement of the land from agricultural pursuits." The report proposed a 4-year revegetation and treatment program on roughly 7,500 acres. Revegetation was accomplished with native grass species such as buffalo grass, blue grama, western wheatgrass, and sand dropseed. The source of the seed (local or otherwise) was not recorded. Wind Cave National Park continued targeted reseeding after the SCS reveg program from 1956 to 1960.

The goals of revegetation in Wind Cave National Park in the first decades after the park was fenced were soil stabilization and adequate forage production of native grasses to support bison. From a landscape view today, it is clear these goals were reached – and it was a major accomplishment. However, a closer look is needed to determine whether the vegetation goals of more recent decades, namely the support and maintenance of native local midgrass prairie (including high native plant species biodiversity with genetic diversity), are being achieved. From this newer perspective, the park vegetation is still a revegetation project in progress. Recent research suggests that restoring native prairie and its signature high plant biodiversity is not simple. While dominant plant species (particularly grasses) may be reintroduced/reseeded, less common grasses and forbs may not be as easy to re-establish. If the disturbed area is very large and/or the area around it does not harbor native seed/vegetative sources to provide seed rain or rhizomatous growth, the full complement of native species may not return. Research results show that one of the most difficult goals to achieve in prairie restoration is a long-term, high plant species biodiversity like that found in undisturbed prairie remnants (Prairie Revival: Researchers Put Restoration to the Test, Allen 2007).

1937 photograph of Wind Cave NP from Elk Mountain.

It is likely that the park contains a mosaic of prairie areas with differing levels of native qualities, since past human disturbance was not homogeneously applied. Inventory and mapping prairie areas with high plant biodiversity, rich soil fungi, or other indicators could help in determining locations of high quality remnant prairie within the park. These locations would be valuable to identify as target areas for conservation priority within the park. They would also be the best seed sources for local genetic seed for revegetation projects in the park. Inventory/mapping would also identify low quality prairie areas that could be monitored to determine if trends to improved quality are occurring without intervention. Low quality prairie areas could then be prioritized for site-specific rehabilitation projects.

Revegetation: BACKGROUND

<u>What is revegetation?</u> Causing land to bear a new cover of vegetation

<u>When does it occur?</u> After disturbance that displaces existing vegetation

Why assist in revegetation? When deemed necessary, to stimulate the natural process of plant community development following disturbance

Who might be involved? Botanists, plant ecologists, vegetation managers, wildlife biologists, soil scientists, hydrologists, cultural resources specialists, and others

Ecological rule of thumb - disturbances happen! Disturbances may be light, moderate, or severe. They can be natural or man-made. However, disturbances are an inescapable dynamic on earth. The severity of a disturbance lays the groundwork for revegetation potential. Light disturbance that destroys vegetation but leaves organic matter intact has high potential for recovery and requires little assistance. Moderate disturbance that removes organic matter and exposes mineral soil has high revegetation potential, especially from off-site seed sources and assisted revegetation. Severe disturbance that exposes subsurface materials has low potential for revegetation.

Wildfire is a natural disturbance that has been suppressed on the Black Hills landscape for many years. The dynamic is replaced by man-made prescribed fire in Wind Cave NP – and post-fire revegetation is not assisted.

Natural disturbances of all types and levels (from wildfires to floods to windstorms to volcanic eruptions) are a natural dynamic that allows ecosystems to cycle through plant succession. Without intervention by humans, ecosystems experience revegetation with early seral stages of vegetation followed by mid seral stages and then late seral stages. Late seral plant communities are composed of plant species that are stable with prevailing conditions and persist on the landscape – until the next disturbance! A mosaic of vegetation in different seral stages on a landscape results in a rich total biodiversity of plants and is important in ecosystem resilience. There is generally no benefit to a natural system to shortcut revegetation/succession by skipping early seral stages and rushing into late seral stages. However, human desires and expectations of a natural system may be different than the natural process/timeline.

Why should people assist in revegetation? Often they should not! If a disturbance is light or small, seed rain or rhizome growth from adjacent areas can easily re-establish native plant cover. The best case is filling in a disturbance with native species having local genetics that are adapted to local growing conditions. Even if a disturbance is moderate or severe, assistance by people is not necessarily the best choice. As an example, in the NPS Burned Area Emergency Recovery (BAER) program, BAER personnel do not try to replace what is damaged by fire but work to reduce further damage due to land temporarily exposed in a fragile condition. In most cases, only a portion of a burned area is treated, such as severely burned areas, fragile slopes above homes, municipal water supplies, or areas around other valuable facilities. Allowing an ecosystem to cycle through the seral stages of succession after a wildfire, even if it takes a long time, is most desirable from a biological perspective.

People assist with revegetation today because there are more and more human-introduced complications to succession, the most common one being introduction of non-native invasive species. If the succession of seral stages is altered or becomes fixed at some stage, ecosystem structure and function may be permanently changed. Invasive species can cause this to happen. A second complication is that some man-made disturbances have no relation to natural disturbances. If a man-made disturbance moves an ecosystem beyond its ability to recover and repair, assistance may be required to achieve revegetation. For example, in some mining situations, the original native plant species and communities are not able to survive in the man-made, post-disturbance environment. Intervention is necessary, sometimes with non-native but noninvasive species, to get a vegetation cover established that will halt erosion and provide site stability.

The first steps in a revegetation project are to analyze site characteristics that affect plant establishment and growth and set revegetation goals. The National Park Service mission to preserve park resources unimpaired for future generations leads to revegetation goals that include conserving the park's native species and genotypes. At Wind Cave National Park, the ideal revegetation goal is establishment of native species with a local genotype.

There is lively ongoing scientific discussion about the importance of local genetics. The impacts of most plant genotypes interacting with the environment are not easy to discern and have not been well studied to date.

However, it has been established for trees that poor survival and/or growth may result if seedlings are not adapted to environmental conditions at the planting location. Most people have had first-hand experience with selecting trees for planting by zones based on the origin of seeds/trees. The value of local genetics would be expected to be similar for herbaceous plants. In addition, it is believed that local genetics provide variability across a species' range of genetics that may be important for the species' long-term survival.

Revegetation: PRESENT

When natural disturbances (fire, flood, drought, prairie dogs, etc.) occur in Wind Cave NP, the first choice is to let ecosystems cycle through revegetation/succession without assistance. One case where human assistance has been applied to natural disturbance in the park is invasive species infestations in early seral stages of vegetation, particularly on prairie dog towns. In these situations, invasive species [such as Canada thistle (*Cirsium arvense*) and horehound (*Marrubium vulgare*)] displace early seral native species and prevent later seral native species from coming in when the disturbance ends or moves away. These projects focused on removing the invasive species to allow native species to move in from seed rain/rhizome growth (that is, they did not involve any planting), so they may not be immediately recognizable as revegetation projects. However, since the goal of the projects meet the revegetation definition of: "cause the land to bear a new cover of vegetation", they clearly are revegetation projects.

Most cases of traditional assisted-revegetation projects in the park are related to man-made disturbance from park management/development. The goal in assisting revegetation in these cases is to encourage re-establishment of native species and communities through seral stages of succession and preventing opportunities for non-native invasive species establishment in the park. Considering the goal of preventing invasive species opportunities, one of the most important and effective tools for park managers is to emphasize a minimal disturbance footprint when designing park projects.

Wind Cave NP has been considering revegetation issues and trying to fill data gaps on what works and what hasn't on past projects. A research study of revegetation in a small waterline disturbance created in Wind Cave NP in 2000-2001 was conducted by Amy Symstad, USGS scientist in 2004-2006. The study quantitatively evaluated the success after 5 years of native grass revegetation using native species of non-local origin. There was also a revegetation component to the sewage lagoon relocation project in 2006, where native species of non-local origin were planted in the old lagoon area. Guidance from National Park Service Management Policies 2006 states that: "Landscape revegetation efforts will use seeds, cuttings, or transplants representing species and gene pools native to the ecological portion of the park in which the restoration project is occurring." While native plant materials with local genetics are preferred, there hasn't been a source to acquire them for Wind Cave NP projects to date.

Park Superintendent Davila helping with planting local genetic native plants behind amphitheater in Elk Mountain Campground on waterline disturbance in June 2009.

The Elk Mountain Campground waterline upgrade project of spring 2009 disturbed a significant amount of native vegetation. Revegetation was completed by contract, using native species of non-local origin. However, plants grown from seed collected at Wind Cave NP (that is, local genetic material) at the NRCS Plant Materials Center in Bismarck became available over the winter. Wind Cave NP vegetation personnel picked up the Wind Cave NP-origin plants and staff and volunteers planted them in part of the waterline project area behind the amphitheater. Planting grown plants as well as seeds should assist in quicker native species establishment; the use of local genetic material will conserve the local genetics and may increase chances of long-term success of the revegetation. Resource Management - Vegetation personnel are monitoring this revegetation project to document results.

Revegetation: FUTURE

In some parts of the country, such as the Pacific Northwest, there are networks of private and commercial and public entities that support a thriving cooperative business in native plant materials with local genetics. The Northern Great Plains, in general, and Black Hills, in specific, has been slow in recognizing the need for native plant materials and slow in taking steps toward developing partnerships, infrastructure, etc. to provide them.

Some of the challenging aspects of designing/developing a native plant material program include:

1) demand for native plant materials in the long-term for revegetation projects is certain, but demand in the short-term is not constant and there is high variability from year to year;
2) an investment is required to set up infrastructure to establish and maintain plants that are mature enough to produce seed;
3) native species are generally more difficult to germinate and grow than horticultural species;
4) if seed are collected from the wild rather than grown, seed production and viability varies dramatically from year to year; also, specialized equipment which requires investment greatly increases seed collection efficiency;
5) a seed storage system that protects viability is required to stockpile seed until demand occurs.

Western wheatgrass growing at NRCS Bismarck Plant Materials Center in June 2009 from seed collected at Badlands National Park. Greater volume of viable seed will be produced for an upcoming road project in the Badlands NP than could be wild-collected.

The U.S. Forest Service Rocky Mountain Research Station in Rapid City, SD, has been working with the Black Hills National Forest in recent years to develop a demonstration plot of local genetic native species for seed production and has initiated some small pilot projects involving revegetation with local genetic native plant material. Personnel in Wind Cave NP vegetation management are talking to Forest Service people and others about a number of possibilities for developing local genetic native plant materials, from some kind of Northern Great Plains multiple park unit project to a Black Hills Area joint interagency effort. It seems that a broad-based approach to a long-term effort may be able to succeed where efforts on smaller scales have failed.

It is hoped that Wind Cave NP will have an opportunity collaborate in the future with others in the Black Hills and Northern Great Plains area to design and develop a native plant material program that meets revegetation needs of this region on public lands, and could also contribute to revegetation on private lands (that is, provide material for citizen use in home landscaping with environmentally friendly native plant materials).

PLANT SPOTLIGHT:
Evax prolifera By Marie Curtin

Evax prolifera, a diminutive, blue-gray forb, was located in Wind Cave NP in July 2008. The species had appeared on the park's plant list previous to this find, but was considered a False Report as there was no confirming voucher specimen in the museum collection. Common names for this forb include rabbit tobacco and bighead pygmy cudweed.

Within the Great Plains, *Evax prolifera* occurs infrequently to locally commonly in prairies, pastures, and stream valleys. It is relatively common in Kansas, Colorado, Oklahoma and Texas, but is also located in South Dakota and Arizona.

The population at Wind Cave NP was discovered adjacent to a horehound infestation in the Bison Flats prairie dog town. Efforts to control horehound with herbicides should take into consideration this small population of *Evax prolifera*.

HARDWOOD REFUGIA

By Marie Curtin

At Wind Cave National Park, three natural refugia and several fenced exclosures provide limited protection from wildlife for several of the eleven species of native hardwoods that occur in the park. The eleven species are:

Acer negundo	Box elder
Betula papyrifera	Paper birch
Celtis occidentalis	Hackberry
Fraxinus pennsylvanica	Green ash
Populus angustifolia	Narrowleaf cottonwood
Populus deltoides	Plains cottonwood
Populus tremuloides	Quaking aspen
Populus x acuminata	Lanceleaf cottonwood
Quercus macrocarpa	Bur oak
Salix amygdaloides	Peachleaf willow
Ulmus americana	American elm

Several of these species can be seen from U.S. Highway 385, at the west entrance to the park. A natural refugium exists at this location, where Cold Springs Creek flows through a meadow surrounded by steep slopes and the park's boundary fence. Wildlife, particularly elk, spend little time in the area and the vegetation is browsed relatively lightly compared to other areas of the park. Green ash, box elder, lanceleaf cottonwood, plains cottonwood and quaking aspen occur in the area. Unfortunately, even in this location aspen show signs of browsing, rubbing, and girdling by wildlife, and cottonwood regeneration has not been observed.

West entrance to Wind Cave NP – hardwood refugium

Another natural refugium exists along Route 87, at the pigtail bridge. Four separate clones of quaking aspen occur here, as well as populations of paper birch, oak and plains cottonwood, a testament to the fact that elk prefer to browse away from roads. Several oaks within the pigtail of the bridge have managed to grow beyond the seedling stage, and are the only known young oak trees surviving outside of a wildlife exclosure located several hundred meters south in Reaves Gulch.

Pigtail bridge hardwood refugium

Reaves Gulch is also home to the Park's one narrowleaf cottonwood, a large and rather gnarly tree located at the southern end of the Gulch near its confluence with Beaver Creek. Refugium conditions do not exist at this location, and no seedling or sapling narrowleaf cottonwoods have been observed.

Narrowleaf cottonwood tree

Peachleaf willow trees occur along Cold Springs Creek and Beaver Creek. Refugium conditions do not exist to protect these willows, and there are no known seedlings or saplings.

Hackberry occur in a natural refugium located in a woody draw that feeds into the Highland Creek drainage. Some ungulates do manage to access this somewhat protected area; all hackberry saplings are hedged from repeated browse activity.

Hackberry refugium

Fourteen aspen clones have been documented at the park. Eight clones are surviving relatively well due to locations near roads and buildings, or within two fenced wildlife exclosures. The remaining clones eek out an existence within talus slopes or on inaccessible cliff ledges. Regeneration at these locations is hedged from repeated browse activity.

Aspen refugium in talus slope

Populations of lanceleaf and plains cottonwood are protected within a wildlife exclosure established adjacent to NPS-6 in the Red Valley where both species are successfully producing new trees. A majority of the Park's cottonwoods occur outside refugia. Most of these trees are reaching the end of their natural life cycle and are slowly dying, with fewer branches leafing out each year.

Five additional hardwood species that are not native to this area also occur at the Park:

Elaeagnus angustifolia	Russian olive
Populus alba	silver poplar, white poplar
Rhamnus cathartica	common buckthorn
Salix alba	yellowstem white willow
Ulmus pumila	Siberian elm

PLANT SPOTLIGHT:
Cacti By Marie Curtin

Six species of cacti have been documented at the Park, including one species, the hedgehog cactus that is tracked by the South Dakota Natural Heritage Program. The six species are:

Echinocereus viridiflorus	hedgehog cactus
Escobaria missouriensis var. *missouriensis*	Missouri pincushion
Escobaria vivipara var. *vivipara*	purple pincushion
Opuntia fragilis	fragile pricklypear
Opuntia macrorhiza	bigroot pricklypear
Opuntia polyacantha	plains pricklypear

It is sometimes difficult to distinguish one cactus species from another. Knowledge of a few characteristics can help with differentiation.

Hedgehog cactus vs. pincushion cacti
The hedgehog cactus, tracked by the Natural Heritage Program to determine whether or not it is imperiled, has vertical ribs while pincushion cacti have spirally arranged tubercles.

Echinocereus viridiflorus

Currently the hedgehog cactus has a Global Rank of G5 (demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery), and a State Rank of SU (possibly in peril, but status uncertain, more information needed). This cactus is common throughout the Park, and during May and June produces green flowers borne on the ribs.

Escobaria missouriensis var. *missouriensis*

Of the Park's two pincushion species, purple pincushion is the longest bloomer, producing pink to reddish purple flowers from May through August. Missouri pincushion blooms during June and July, producing pale yellow to greenish flowers, often tinged with pink.

Pricklypear

Of the three species of pricklypear occurring at the Park, the fragile pricklypear is the easiest to identify due to ovoid stem segments that readily detach from the plant and cling to fur and clothing by barbed spines. Fragile pricklypear flowers during June and July, producing yellow to greenish flowers.

Bigroot pricklypear has flat stem segments (pads) with spines mostly on the uppermost sections of the stems, and often only on the stem margins. It flowers during May and June, producing yellow to reddish flowers. Plains pricklypear also has flat stem segments, but has spines that are smaller and are distributed over the entire stem.

Opuntia macrorhiza

Making a Digital Color Map of Wind Cave

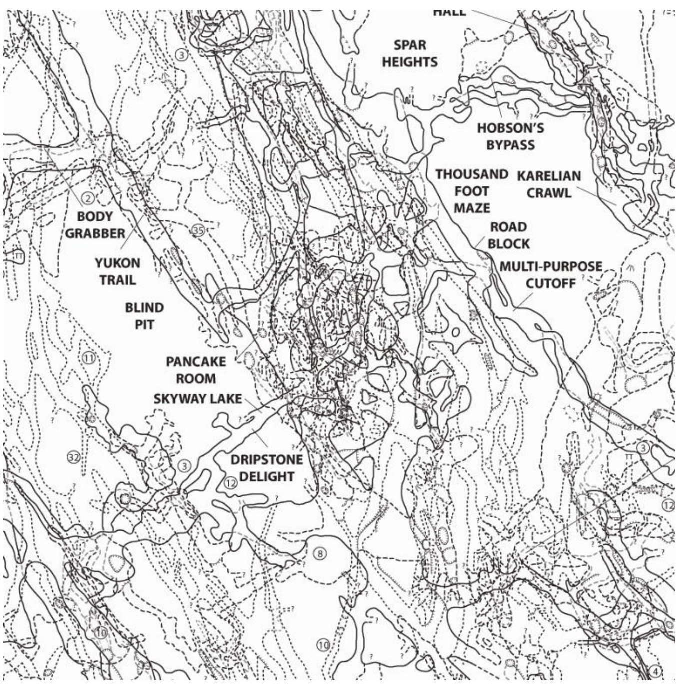
By Rodney D. Horrocks & Daniel C. Austin

A decade ago, we realized that the park needed either a wall-sized map of Wind Cave or an interactive map on a computer screen. We decided that the best way to accomplish either of these was to create a digital map. Once we had a digital map, we would also be able to use it for the web site, brochures, and a new poster map of the cave. A digital map would also make it easier for the Physical Science Office to add new surveys to the cave quadrangles, find and fix errors on the map, and add additional detail that had been previously left off of the quadrangles. All we had to do was to divide all the elements of the map into individual layers that could be turned on or off, depending on the desired end product. However, the software available to us a decade ago wouldn't allow us to create the colorized, multilevel map we envisioned. So, we started on a Mylar-based quadrangle map system that would set the ground work for the time when the software became available.

When this process began in 1999, there were 17 named quadrangles for Wind Cave drawn in pencil on butcher paper. In plan view, each of those quadrangles covered 1,500 feet by 1,000 feet. Even though only 78 miles of survey had been drafted onto those quadrangles, they were already getting impossibly complicated, as each quad contained all three cave levels superimposed on top of each other in their actual relational positions. The two lower levels were shown utilizing a system of dashes and dots for the walls, making it very difficult to use the maps. The first cartographic step to make the new quadrangles involved creating a digital template in Adobe Illustrator® that was printed onto Mylar sheets at a scale of 50'/inch. Each quadrangle was divided into three layers, each on its own Mylar sheet: the upper, middle, and lower layers, which increased the number of quadrangles from 17 to 38. Each quadrangle now contained an index location map, a legend, and the cartographic history of that quad. We then traced the passages from each of the old quads onto three new Mylar quads for each named quadrangle, adjusting the passages as we drew to fit a corrected lineplot of the cave. The final step involved adding all of the backlog cave surveys (45 miles of survey data) to the new Mylar quadrangle maps.

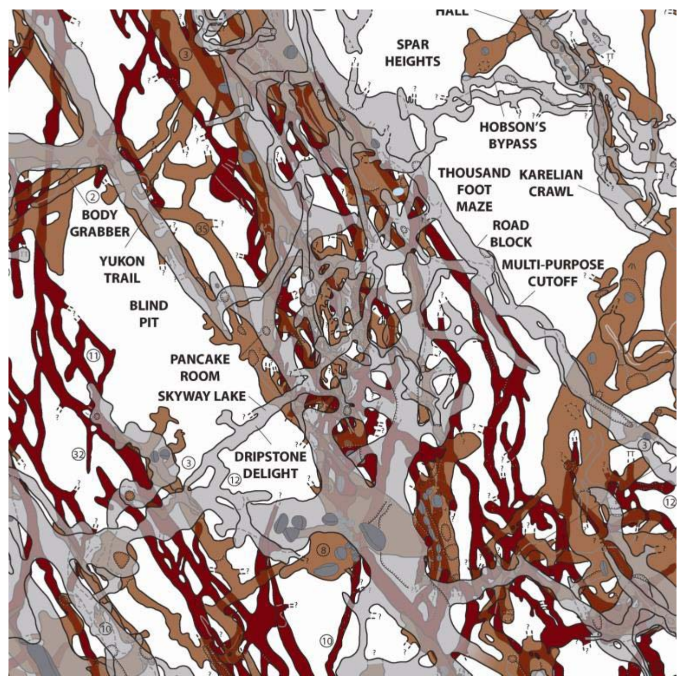
Eight years after we started the Mylar quadrangle project and soon after finishing them, the necessary feature required to make our digital map was added to

Illustrator. The critical new feature that allowed making a digital map of this complex cave even possible was the transparency feature. We needed to be able to see the underlying passages, since many parts of Wind Cave have from 3-5 layers superimposed on top of each other (see accompanying figures). To visually simplify things, we needed the underlying passages to be a continuous color that could be easily discernable from the other two layers. The first step involved scanning all of the Mylar quadrangles as individual JPEG images. With the help of David Lambert, a volunteer National Geographic Cartographer, we created a digital template for the new quadrangles in Adobe Illustrator®. From this first digital template, we found that the cave passages could easily be produced and saved into a single Illustrator file that allowed the user to turn cave layers on or off. Further refining the process, we then created a master quadrangle template that was divided into an upper, middle, and lower layer. Each layer was further subdivided into individual cartographic elements (walls, ceiling heights, ledges, place names, etc.).



A portion of the Club Room Quadrangle shown in the traditional method of using dashes and dots to represent lower passages.

Color was used to combine the multiple three-dimensional levels onto a two-dimensional map. Each of the three major layers was assigned a color (reddish brown for lower, brown for middle, and light gray for the upper layer). The digitization of the 38 quadrangles took three people nearly a year to complete. Once the 17 master digital quadrangles were completed, each master quad was then stitched to the adjoining quads, beginning in the southwest corner of the cave. This resulted in a single 10 x 12 foot digital colorized map of Wind Cave. This large-scale map will now be printed onto a special plotter paper and displayed at the International Congress of Speleology in Texas this July. This map, which shows 121 miles of passages, will be displayed on a giant patio at the same scale and next to three of the four longest caves in the United States (Mammoth, Lechuguilla, and Jewel Caves). Although Wind Cave will have the smallest footprint of the four maps, it will be the most complex cave and the only one in color. Participants in the Congress will be able to walk on top of these maps, comparing the footprint, passage patterns, and the number of unsurveyed leads between each cave. It should be an unprecedented and monumental display.



The same portion of the Club Room Quadrangle that uses color and transparences to represent lower passages. Notice how much simpler it is to visually discern which layer a passage belongs to in the colorized version.

Even though we now have a digital map of Wind Cave, we are far from finished with our ambitious project. The next step will involve adding 11 miles of backlogged survey data, fixing problems discovered during the digitizing process, adding additional interior passage detail for nearly 80 miles of cave, and tying the survey stations in the Illustrator file to the stations in COMPASS. This round-tripping procedure will allow the digital cave map to be adjusted every time a new loop is closed in the survey data. Once these tasks have all been completed, the park will have a digital map of Wind Cave that can be used for a giant wall display, for a new poster, or for an interactive digital map on a large monitor. Each of those maps could be easily created by turning on or off individual layers in the Illustrator® file. Furthermore, the digitization and combination of the entire cave into one single cohesive file will allow us to better manage and understand this incredible resource beneath our feet. To our knowledge, this is the longest and most complex cave in the world to have been drawn as a single large-scale colorized digital map.

Wildlife Management Activities and Invitation

By Dan Roddy

Wind Cave NP Resource Management -Wildlife plans for a busy summer! If anything catches your interest or you think you may want to be involved with a particular project, please stop by and chat with Barb, Duane or Dan.

Bioacoustic monitoring of birds and herps (May)
Tiger salamander research (June/July) – study effects from insecticide used to treat fleas
Flea monitoring (for plague detection) (June/July/August)
Elk cow/calf counts (June/July/August)
Bison calf counts (June/July/August)
Wildlife disease surveillance (year round)
Breeding bird surveys by park staff (roadside and off-road) (June)
Breeding bird surveys by Rocky Mountain Bird Observatory (May/June/July)
Raptor nest monitoring of 40+ nests in the park (April-July)
Nightjar survey (June 29 - July 15th).
GPS mapping of prairie dog towns (all summer)
Complete Elk Management Plan / Environmental Impact Statement (June)
Dusting prairie dog burrows for plague prevention (August-Research Reserve)
Pronghorn survey (September)
Black-footed ferret surveys and trapping kits (September)
Bison round-up (October)